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SECTION OF BIOLOGY[1]

JANUARY 9, 1939

DOCTOR H. HERBERT JOHNSON, College of the City of New York: *Twins, Normal and Abnormal.* (This lecture was illustrated by lantern slides, clay models, and specimens.)

In spite of the familiarity of the topic, it is obvious that much is still to be learned concerning the exact origin in embryo of human twins and partial twins, while at the same time there exist widespread misconceptions regarding the phenomenon of twinning. A review of current ideas bearing upon the problem seems timely, especially since opportunity is given to illustrate some points with preserved specimens of unusual interest. No attempt is made here to present very original points of view on the matter, and the discussion is limited to well known theories of special interest to the embryologist.

Dizygotic ("fraternal" or two-egg) human twins theoretically may result from any one of three possibilities: 1. More or less simultaneous ovulation from both ovaries; 2. Ovulation, at about the same time, of more than one follicle in a single ovary; 3. Ovulation of a single follicle containing two or more ova. Evidence is presented that such biovate or polyovate follicles are much more frequent than is generally believed. The exhib-

[1] No meetings were held in January by the Sections of Geology and Anthropology.

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its include examples from the pig, rabbit, dog, cat and monkey. The view of Maximov that such follicles are characteristic of young females, is not supported by this investigation.

It is now quite generally accepted that about one fourth of all twins are monozygotic ("identical" or single-egg) but no single line of evidence gives irrefutable proof that monozygotic twins exist. The various sources of evidence which collectively tend to establish proof of single-egg twins are reviewed in the recent book by Newman *et al.*[1]

Statistical evidence is gleaned from the fact that same-sexed twins occur more frequently than opposite-sexed twins, whereas the genetic expectation is a 1 : 1 ratio of same-sexed to opposite-sexed pairs. The weakness in this line of evidence when considered alone lies in the assumption that opposite-sexed twins are equally viable in utero as same-sexed pairs, and are in no way subject to environmental sex changing disturbances such as have been demonstrated experimentally in other higher vertebrates.

Very important is the fact that conjoined twins are always of the same sex, and so are twins born in a single chorion. Until 1928 it was generally believed that *all* monozygotic twins develop in a common chorionic envelope. In 1927 Komai stated: "Apart from the examination of the placenta and foetal membranes at birth, there is *no* safe criterion of distinguishing the identical twins from the fraternal twins."[2]

The fact that identical twins are so frequently monochorial refutes a widespread dogma that such individuals originate by a splitting apart of the blastomeres at first cleavage. This point of view results from a misguided application to the human egg of the classical *experimental* results obtained on other forms. Chabry, Herbst, Driesch, Wilson *et al.* obtained more or less "normal" development of certain marine invertebrates and of Amphioxus from single blastomeres isolated experimentally during early cleavage. It should be emphasized that

[1] Newman, Freeman, and Holzinger. "Twins: A Study of Heredity and Environment." University of Chicago Press, 1937.

[2] Komai, Taku. Science, 65: 280. 1927.

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these eggs do not self-isolate their own blastomeres. There may be no theoretical reason why the human ovum, or that of any mammal, might not divide at a stage in early cleavage into entirely separated blastomeres each capable of producing a complete body. The presence of the single chorionic envelope, however, shows that this is not usually the case. Since the chorion in the mammal embryo is developed from the outer layer of cells of the blastula and the embryo results from a clump of more centrally placed cells, it is obvious that the real division of the body in such cases results from the separation of this inner cell mass at a comparatively advanced stage of blastula formation. Such duplicated inner cell masses have been described in the armadillo by Patterson, the sheep by Assheton, and the human by Arey.[3,4]

Since 1928 some evidence has accumulated to show that perhaps a few monozygotic twins are indeed dichorial. The case of identical triplets described by Komai and Fukuoko,[5] 1931, is not altogether conclusive when considered alone. Two bodies were produced in a chorion, and the third was in a separate chorion attached to the first. Komai interpreted this as a fusion of two separate chorions, but it could almost equally be called a faulty separation of one. Other evidence for dichorial identical twinning is presented by Curtius[6] and Lassen.[7] It is still unknown whether these cases really represent a separation of early blastomeres, or a constriction of the chorion at a much later stage, perhaps while invasion of the uterine wall is taking place.

Duplication of body parts occurs in an extensive series ranging from duplication of a single digit or the palm of the hand to duplication of the entire limb, the head, or practically the entire body (the conjoined, or "Siamese" twin). Conjoined

[3] Arey, L. B. Anat. Rec., 23, 1922.

[4] Arey, L. B. "Developmental Anatomy," 3rd Ed., p. 154, 1934. W. B. Saunders, Publisher.

[5] Komai, Taku and Goro Fukuoka. Jour. of Hered., 22, 1931.

[6] Curtius, F. Zeitschrift für Konstitutionslehre, 13, 1928.

[7] M. T. Lassen. Archiv für Gynakologie, 147, 1931.

twins apparently arise later in gastrulation than identical twins. The dissimilarity of the individuals has been explained in a view advanced by Newman.[8] One is developed entirely from that part of the embryonic disc previously differentiated as left, and the other from the corresponding rudiment already determined as right. Each rudiment restores the missing portion in mirror-image symmetry to itself. Thus the two bodies differ to about the same degree as is frequently seen in the left and right sides of an ordinary person.

After reviewing various theories as to the basic causative factor leading to embryonic axial duplication, the theory of developmental arrest, advanced especially by Stockard,[9] still seems to be, in a general way, the best interpretation. The Spemann school has shown that the portion of the embryonic disc capable of being organized to produce a head is a considerably larger field than is actually necessary to produce a head. The center is the more responsive portion of this field. If a developmental arrest occurs precisely at the time that evocatory stimulation, capable of organizing a head, is expected, the center of the field is retarded and loses its power of development. If the retarding factor then ceases to operate, some power of organization still is retained by the more lateral portions of the head-field, and these separately begin development, thus forming a duplicated head. Similar arrest, occurring at the critical moment at which gastrulation should begin, might similarly result in the appearance of two gastrulation points on a single embryonic disc. The degree of mechanical and physiological separation of these centers is in direct ratio to the degree of separation exhibited by the resulting twins.

Specimens exhibited included a foetal pig with duplicated snout and jaws, and three eyes; a human foetus of five months with two complete heads, four shoulders, and three arms; a human octopus, with two nearly complete bodies joined at the pelvis. These specimens, and others shown, are part of the collection of the Division of Embryology of the College of the City of New York.

[8] Newman, H. H. Journ. of Hered., 22, 1931.

[9] Stockard, C. R. Amer. Jour. Anat., 28, 1921.

SECTION OF PSYCHOLOGY

JANUARY 16, 1939

PROFESSOR JOHN A. MCGEOGH, Wesleyan University: *Conditions of Human Forgetting.*

The decrements in learned performance which are correlated with the passage of time without practice were one of the first phenomena of human learning and memory to be studied experimentally (Ebbinghaus). There has been until recently small interest in the conditions which produce these decrements, that is, in forgetting. This is the more strange in view of the way in which forgetting pervades both formal learning and everyday experience. It is present in all formal learning and among other things is basic to the form of learning curves. In daily life it reaches from the forgotten errand to the largely forgotten body of knowledge.

Within the last few years attempts to account for forgetting have been made within the level of the phenomenon to be explained. Two major conditions have been discovered experimentally: interference from interpolated activity (retroactive inhibition) and changed stimulating conditions.

Retroactive inhibition, first described by Müller and Pilzecker at the turn of the century, has been the more studied of the two. It refers to the disintegrating influence exerted by a subsequent activity upon the retention of something which has been learned antecedently. A better definition is the operational one provided in the experimental paradigm:

Control condition:	Learn (1)	Rest	Measure retention of (1)
Experimental condition:	Learn (2)	Learn (3)	Measure retention of (2)

The interval between learning and the measurement of retention is the same under the two conditions and other factors are kept as constant as possible. The difference lies in the interpolated learning (3) under the experimental condition. If retention under this condition is less than it is under the con-

trol, this greater decrement is the phenomenon called retroactive inhibition.

It has been found in the laboratory with a wide range of materials and of learners. It appears with all groups of subjects who have thus far been studied, with both meaningless and meaningful materials, and by all methods of measuring retention. Its amount may vary from a percent or two to 90 percent or higher. The amount in which it appears is a function of a number of conditions.

One of the most general of these conditions is the relation (usually called similarity) between the material first learned (original material) and the interpolated material. The similarity between these two may be of several kinds or dimensions. (1) Especially when the materials are serial lists, they may vary in degree of identity of formal construction, as when the two halves of a memory span have varying percentages of common terms or two lists of syllables contain terms with common letters. (2) The two materials may vary in similarity of meaning, as when the original list is composed of adjectives, the interpolated list of their synonyms or their antonyms, of unrelated adjectives, nonsense syllables or three-place numbers. (3) The two may be similar, not in themselves, but in the ways in which they are presented or dealt with by the subject.

Retroaction varies with percentage of identity, decreasing in the memory span case as the percentage decreases. Similarity is difficult to quantify, but it can at least be ranked by competent judges. In a considerable number of experiments it has been found that as similarity decreases from near identity amount of retroactive inhibition decreases, until it approaches zero as the similarities between the two materials become slight.

Other conditions of which it is a function are degree of learning of both original and interpolated materials, the instruction to and set of the subject, and the amount of material to be learned.

It is certain that interpolated activity produces a decrement under the conditions of the laboratory. Are formally learned

materials susceptible to interference from the activities of daily life? This has been answered in the affirmative by several different experiments, the first of which was by Jenkins and Dallenbach. They found that lists of nonsense syllables were forgotten according to the classical Ebbinghaus curve when the subjects went about their ordinary daily activities during from one to eight hours following learning. When sleep filled the interval, however, the retention curve dropped during the first two hours, though less rapidly than when waking activity intervened, but did not fall thereafter.

Two theories have been offered to account for the interference produced by interpolated activity. The perseveration theory holds that the neural activities involved in learning perseverate (continue) for some time after practice ceases, thus giving a kind of gratuitous practice. Interpolated activity damps this perseveration. This theory lacks sufficient neurological basis and is, moreover, unable to incorporate the behavioral facts. The transfer theory, on the other hand, holds that the interference is a matter of confusion between the materials or methods of the original and interpolated activities, and is a form of negative transfer. The facts of the experiments on similarity support this strongly, as does the discovery that specific parts of each one of the two activities actually carry over and become incorporated into the other.

A second condition of forgetting, though it has been less explored by experiment, is an altered stimulating condition. Everything learned is learned in response to stimuli, and measured retention is in response to a part of the original stimulus situation. If the stimulating conditions at the time of attempted recall are sufficiently different from those during learning, recall will fail.

The experiments by Pan, Dulsky and others have begun an exploration of the changes in stimulating context which will produce forgetting. It seems that not all changes will yield a decrement; some certainly will. The operation of this condition in daily life is seen in the failure to recall the name of an

acquaintance when met in a new environment, or the inability to recall a recently known fact when not in the classroom or study where it was learned.

Other conditions, not yet experimentally studied, may operate to produce forgetting. Enough is known of the influence of these two, however, to make one wonder that we remember anything, rather than why we forget as much as we do. In actual life each new experience serves as interpolation after the experience that went before, and after each experience interpolations progressively accumulate. We seldom try to recall in the same context of stimuli as that in which the material was learned. That we retain as much as we do is a function of a favorable combination of the conditions which determine amount of retroactive inhibition and of forgetting from altered stimulation. Research upon these conditions has only recently been begun and offers a wealth of experimental problems.

ANNOUNCEMENT OF PUBLICATIONS FOR 1939

The following publications will be issued by the Academy during the current year. Members of the Academy who desire to receive these papers will kindly request the Executive Secretary to send them, and they will be mailed, free of charge, as they are ready for distribution except as qualified in the footnotes:[1]

SPECIAL PUBLICATIONS:

1. VOLUME I. CLIMATE AND EVOLUTION. By William Diller Matthew. Enlarged and revised to include the following papers:
   "Climate and Evolution," by William Diller Matthew.
   "Some Remarks upon Matthew's 'Climate and Evolution,'" by T. Barbour; with Supplementary Note by William Diller Matthew.
   "Note on the Wegener Hypothesis, Supplementary to 'Climate and Evolution,'" by William Diller Matthew. (Previously unpublished.)
   "Affinities and Origin of the Antillean Mammals," by William Diller Matthew.
   "The Dispersal of Land Mammals," by William Diller Matthew.
   "The Outline and General Principles of the History of Life," Synopsis of lectures in Palæontology I, University of California Syllabus, Series 213, Figs. 8–12 (Tables Showing the Past and Present Zoogeographical Distribution of Land Mammals), by William Diller Matthew.
   "Annotated Bibliography of William Diller Matthew," by Charles Lewis Camp and Vertress Lawrence VanderHoof.

[1] Student and Associate Members are entitled to receive one complete monograph or up to 150 pages.

ANNALS:

2. "Constitution and By-Laws, including a full membership list." This will be sent to all members.
3. "Electrophoresis." This article will contain the five papers delivered at the conference of the Section of Physics and Chemistry, October 28 and 29, 1938. (About 50 pages.)
4. "American Cities and States: Variation and Correlation in Institutions, Activities, and the Personal Qualities of the Residents," by Edward L. Thorndike. (About 104 pages.)
5. "The Morphology and Functional Evolution of the Atlas-Axis Complex from Fish to Mammals," by F. Gaynor Evans. (About 72 pages.)

SCIENTIFIC SURVEY OF PORTO RICO AND THE VIRGIN ISLANDS:[2]

Volume VIII, Part 3: "Diatomaceae," by Robert Hagelstein. Published January 19, 1939.

Volume XVI, Part 2: "Annulata of Porto Rico and the Virgin Islands," by A. L. Treadwell.

Volume XIV, Part 3: "Insects of Porto Rico and the Virgin Islands—Heteroptera," by H. G. Barber.

[2] The Scientific Survey publications are available to Members for $1.50 per part and to non-members for $2.00 per part.

A certain number of parts, as announced each year, are available free to Honorary, Life and Sustaining Members.

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It will be of interest to the members of the Academy for us to publish herewith the list of new members added to the rolls of the Academy during the year from February 7, 1938, to February 6, 1939.

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